Morphological Image Processing

Image Processing
CSE 166
Lecture 15
Announcements

• Assignment 4 is due today, 11:59 PM
• Assignment 5 will be released today
  – Due May 29, 11:59 PM
• Reading
  – Chapter 9: Morphological image processing
    • Sections 9.1, 9.2, 9.3, and 9.5 (through subsection connected components)
Reflection and translation

\[ \hat{B} = \{w \mid w = -b, \text{ for } b \in B \} \]

Reflection

\[ (B)_z = \{c \mid c = b + z, \text{ for } b \in B \} \]

Translation
Sets of pixels: objects and structuring elements (SEs)

Objects represented as sets

Structured element represented as a set

Objects represented as a graphical image

Structured element represented as a graphical image

Digital image

Digital structuring element

Border of background pixels around objects

Tight border around SE
Reflection about the origin

Don’t care elements
Erosion

Example: square SE

\[ A \ominus B = \{ z \mid (B)_{z} \subseteq A \} \]

\[ I \ominus B = \{ z \mid (B)_{z} \subseteq A \text{ and } A \in I \} \cup \{ A^{c} \mid A^{c} \subseteq I \} \]

Complement of A
(i.e., set of elements not in A)
Erosion

Example: elongated SE

\[ A \ominus B = \{ z \mid (B)_z \subseteq A \} \]

\[ I \ominus B = \{ z \mid (B)_z \subseteq A \text{ and } A \in I \} \cup \{ A^c \mid A^c \subseteq I \} \]
Erosion

Shrinks

11x11

15x15

45x45
Dilation

\[ A \oplus B = \{ z \mid (\hat{B})_z \cap A \neq \emptyset \} \]

Examples

Square SE

Elongated SE

CSE 166, Spring 2020
Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company’s software may recognize a date using "00" as 1900 rather than the year 2000.
Opening

Structuring element rolls along inner boundary

\[ A \circ B = (A \ominus B) \oplus B \]
Closing

Structuring element rolls along **outer** boundary
Opening and closing

Dilation

Erosion

Opening

Dilation

Closing
Morphological image processing

Noisy input

Opening

Dilation

Closing

Erosion

Dilation

Erosion
Boundary extraction

Erosion

Set difference
Boundary extraction
Given point in hole

\[ X_k = (X_{k-1} \oplus B) \cap A^c \quad k = 1, 2, \ldots \]
Hole filling

Given points in holes

All holes filled
Connected components

Given point in $A$

$$X_k = (X_{k-1} \oplus B) \cap A \quad k = 1, 2, \ldots$$
Connected components

X-ray image

Threshold (negative)

<table>
<thead>
<tr>
<th>Connected component</th>
<th>No. of pixels in connected comp</th>
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<tbody>
<tr>
<td>01</td>
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15 connected components
Next Lecture

• Image segmentation
• Reading
  – Chapter 10: Image segmentation I: edge detection, thresholding, and region detection
    • Sections 10.1, 10.2, and 10.3